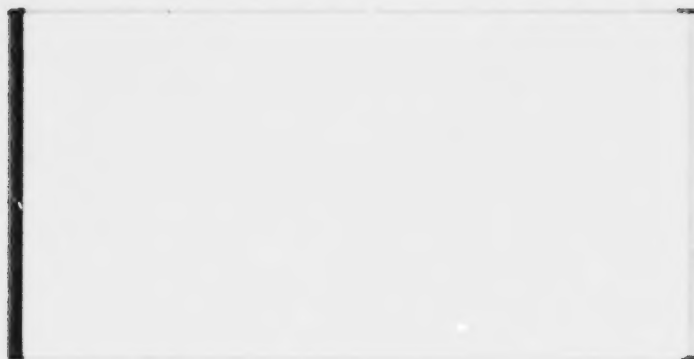




Ontario Hydro





**ontario hydro
research division**

**GALLOPING OCCURRENCES IN CANADA
AND THE UNITED STATES DURING
THE 1984-85 WINTER**

Report No 85-276-K

C.J. Pon
Engineer
Applied Structural and
Solid Mechanics Section
Mechanical Research Department

ABSTRACT

The performance of several galloping control devices has been systematically monitored at test locations on lines in Ontario and the United States since 1977. These and other types of control devices have also been monitored for several years on European lines. More recently, under the auspices of the Canadian Electrical Association, test sites have been established and are being monitored on distribution and bundle lines across Canada. Each year's observations are documented to provide a continuing record of galloping observations made by trained observers. This report is the latest in the series of reports. It describes the performance of galloping control devices on transmission and distribution lines for the 1984-85 winter season. The scope of this report has been expanded from the previous reports to include observations at test sites without control devices and at locations other than test sites. Also, galloping occurrences are reported from across Canada and the United States.

job	file	date	report no.
740621-302-331	825.151	December 3, 1985	85-276-K



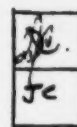
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EXECUTIVE SUMMARY

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UNITED STATES DURING THE 1984-85 WINTER

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The performance of several galloping control devices has been systematically monitored at test locations on lines in Ontario and the United States since 1977. These and other types of control devices have also been monitored for several years on European lines. More recently, under the auspices of the Canadian Electrical Association, test sites have been established and are being monitored on distribution and bundle lines across Canada. Each year's observations are documented to provide a continuing record of galloping observations made by trained observers. This report is the latest in the series of reports. It describes the performance of galloping control devices on transmission and distribution lines for the 1984-85 winter season. The scope of this report has been expanded from the previous reports to include observations at test sites without control devices and at locations other than test sites. Also, galloping occurrences are reported from across Canada and the United States.



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ontario hydro research division

To Mr. F.J. Kee
Director of Research

GALLOPING OCCURRENCES IN CANADA AND THE UNITED STATES DURING THE 1984-85 WINTER

1.0 INTRODUCTION

This report documents occurrences of conductor galloping on transmission and distribution lines throughout Canada and the United States for the 1984-85 winter season. It is the latest in the series of reports/1-7/ which provides a continuing record of galloping observations made by trained observers. The scope of this report has been expanded from the previous reports to include observations at test sites without control devices and at locations other than test sites. Also, galloping occurrences, previously reported from Ontario Hydro sites only, are reported from across Canada and the United States.

The past year produced eleven reported incidences of galloping on Ontario Hydro lines. Nine of the eleven occurrences were observed by trained observers. Seven observations were made at established single or bundle conductor transmission, or distribution test sites. Two more observations were made on lines where no control devices are installed. There were two separate incidences where galloping was the most likely cause of hardware component failures. Although this activity is reported, observations were not made.

There was one reported galloping occurrence on a distribution test site near Cheticamp, Nova Scotia. A description of a vibration problem caused by a control device at a test site near Swift Current is provided. These test sites are part of a CEA sponsored galloping research project on distribution lines across Canada.

In the United States, the Electric Power Research Institute (EPRI) has had galloping test sites in place since 1977. Similar reports/8/ to this have been issued annually since 1978 to document galloping observations made at these sites by trained observers. Although there were no reported observations at EPRI test sites during the 1984-85 winter, galloping was reported at six other sites in the United States.

This report does not attempt to interpret the data but records observations. Interpretations of these observations are considered to be valid only in the context of the accumulated experience of each control device. Summarizing reports have been issued for drag dampers/9/, interphase spacers/10/, and detuning pendulums/11/. A recent report/12/ has attempted to compare these devices and air flow spoilers based on all data available to the end of 1983.

2.0 OBSERVATIONS AT ONTARIO HYDRO SINGLE CONDUCTOR TEST SITES

Manby Test Site

On December 14, 1984, galloping was observed on the four 115 kV circuits immediately south of Manby TS. The site covers four spans of circuits K7B, K8B, K9V and K10V. Four, 25 kg (55 lb) x 5.08 cm (2 inch) detuning pendulums are installed on the middle phase of the K10V circuit. Also installed on the lower phase of that circuit are four, 14.1 kg (31 lb) x 15.24 cm (6 inch) pendulums. The remaining ten phases are used for reference.

Written records taken during the galloping are used to document this occurrence. An estimated 3 mm (1/8") of ice covered the conductors. At the time the observation was taken the temperature was -1°C, the wind was from the east at 16-24 kph (10-15 mph) and there was a mixture of rain and freezing rain. The two phases with the detuning pendulums were galloping at amplitudes up to 0.5 m (1.5 ft) while the ten reference phases galloped at amplitudes up to 2.4 m (8 ft). Most galloping motions were in single loop. A summary of the observation and a map of the test site are contained in Appendix I.

Claireville TS x Richview TS Test Site

On December 14, 1984, mild galloping was observed and recorded at the Claireville TS to Richview TS test site at Rexdale Blvd. The site covers five spans of circuits V71R, V72R, V73R, V74R, V75R, V76R. Three, 14.1 kg (31 lb) x 50.8 cm (20 inch) detuning pendulums and four, 14.1 kg x 30.5 cm (12 inch) pendulums are installed on the lower and middle phases respectively of circuit V72R. Also installed are end point dampers on the upper phase of V72R on four towers only. The remaining 15 phases are used for reference.

During the observation the temperature was at the freezing point, the wind was from the east at 16-24 kph (10-15 mph), the ice thickness was 1.6-2.4 mm (1/16-3/32 inches) and there was freezing drizzle. All phases were quiet except for two spans of the upper phase of V73R and one span of the upper phase of

V74R. The amplitude on one of the upper phases of V73R averaged 1.5 m (5 ft) in irregular one and two loop motion. The amplitudes on the other upper phases of V73R and V74R were not recorded but were noted to be small. A summary of the observation and a map of the test site are contained in Appendix I.

Nanticoke GS x Middleport TS 230 kV Test Site

On December 14, 1984, galloping was observed on a 230 kV circuit at the Nanticoke test site. The site comprises six spans of circuits N5M and N6M. Five, 25 kg (55 lb) x 15.2 cm (6 inch) pendulums are installed on the middle phase of the N5M circuit. The remaining five phases are used for reference.

Only one span of this test site was documented by written notes and a movie film. The temperature was at the freezing point, the wind was from the north-east at 13 kph (8 mph), there was a fine rain and the ice on the conductors was estimated to be 3 mm (1/8 inches). The movie film of the one observed span shows that the phase with pendulums was galloping at 1.2 m (4 ft) in single loop while the five reference phases were quiet. A summary of the observation and a map of the test site are contained in Appendix I.

Manby Test Site

On January 7, 1985, galloping was observed on two spans at the Manby Test site. The details of the site are outlined in the description of the December 14, 1984 observation.

The written report taken at the time of this occurrence shows that the temperature had fallen to -7°C after the freezing rain had stopped. The wind was from the NNE at 6.4-14.4 kph (4-9 mph). Between 1-2 mm (0.04-0.08 inches) of ice remained on the conductors. Two spans were observed to be galloping. On one span, a reference phase was galloping at 1.6 m (5.1 ft) in single loop. One hour later the galloping on that phase stopped but picked up again two hours later with the amplitude increasing to 2.1 m (6.8 ft). Three other reference phases on the same span were also galloping at 1.0 m (3.4 ft). A detuned phase on an adjacent span was galloping slightly at 0.24 m (0.8 ft) in single loop. A summary of the observation and a map of the test site are contained in Appendix I.

Burlington TS x Hamilton Beach TS Test Site

On March 4, 1985, galloping was observed on the three southernmost spans of the site between towers 47-48, 48-49 and 49B-50. Span 47-48 has three, 14.1 kg (31 lb) x 15.2 cm (6 inch) detuning pendulums installed. The other two spans have four,

14.1 kg pendulums. They are installed on the middle phase of B18H between towers 47-48 and 48-49 and on the middle phase of an idle circuit between towers 49B-50.

Written details of the galloping motions were not taken; however movie films were and are used to document this occurrence. The temperature was -2°C and the wind was from the east at 40-56 kph (25-35 mph). The ice thickness on the conductors was about 3 mm (1/8 inch). The detuned phases between towers 47-48 and 48-49 were estimated to be galloping at 0.6 m (2 ft) in two loops. The amplitudes of the reference phases between towers 47-48 were slightly greater at about 0.9 m (3 ft) also in two loops. The reference phases between towers 48-49 were galloping in two loops at about 1.2 m (4 ft). The detuned phase between towers 49B-50 were galloping at 1.8 m (6 ft) in two loops. The conductor motion followed an elliptical shape with the side to side motion about one-half the vertical amplitude. A summary of the observation and a map of the test site are contained in Appendix I.

2.1 Observations at Other Ontario Hydro Single Conductor Sites

Burlington TS x Hamilton Beach TS

On December 14, 1985, galloping was observed on the span immediately south of the Burlington TS - Hamilton Beach TS test site. There are no devices installed between towers 49-50 where the observation was taken.

Although two films were taken, useful information could not be obtained from them. The written report indicated that the temperature was at the freezing point and the wind was from the east at 32 kph (20 mph) with gusts up to 80 kph (50 mph). Precipitation was in the form of sleet and there was about 3 mm (1/8 inch) of ice on the conductors. All phases of B10 and B11 circuits between towers 49-50 were reported galloping at 2.7 m (9 ft) in three loops. A summary of the observation is contained in Appendix II.

Allanburg TS

On December 14, 1985, galloping was observed on the span between towers 56-57 of circuits Q26A, Q28A, Q30A and Q32A near Allanburg TS. There are no control devices installed on these lines.

A written report and movie films were taken during this occurrence. The temperature was at the freezing point and the winds were from the north-east at 32 kph (20 mph) with gusts up to

56 kph (35 mph). Freezing rain had deposited about 1.5 mm (1/16 inch) of ice on the conductors. Galloping amplitudes between 3.7-4.6 m (12-15 ft) were observed in two loops. A summary of the observation is contained in Appendix II.

2.2 Other Galloping Related Activity on Ontario Hydro Single Conductor Lines

Burlington TS x Hamilton Beach TS

Early on January 1, 1985, circuits B10 and B11 experienced several automatic interruptions. A patrol of the line revealed that a loop pad had failed on each of the centre and bottom phases of B10 at tower 46. It is highly probable that conductor galloping caused the interruptions as well as the failed loop pads. A large area of freezing rain, sleet and snow accompanied by high winds passed through the region at the time of the outages.

3.0 OBSERVATION AT ONTARIO HYDRO BUNDLE CONDUCTOR TEST SITES

Milton TS x Trafalgar TS Test Site

On December 14, 1984, galloping was observed on the M572T and M573T four conductor bundle circuits that connect Milton TS to Trafalgar TS. The site comprises two sections of four spans each. A map of the test site in Appendix III illustrates this. Both sections have detuning pendulums installed on the lower phase of the M572T circuit. One section has four, 34.4 kg (76 lbs) x 31.1 cm (12.25 inch) pendulum assemblies per span. The other section has four, 69 kg (152 lbs) x 31.1 cm pendulum assemblies per span. The remaining five phases in each section are used for reference.

Movie films and written observations were made during the galloping occurrence. The temperature was -1°C with the wind from the south-east at 8-32 kph (5-20 mph). Ice up to 3 mm (1/8 inch) thick was recorded. Galloping on these circuits was widespread and all reference phases were galloping at 1.8 m (6 ft) in two loops. The detuned phases were quiet. A summary of the observation and map of the test site are contained in Appendix III.

3.1 Other Galloping Related Activity on Ontario Hydro Bundle Conductor Lines

Lambton GS x St. Clair River Jct (USA)

On March 4, 1985, circuit L51D, an inclined two conductor bundle, was automatically removed from service when a deadend assembly (ie, strain link) failed at the first structure back

from the 102 m (335 ft) crossing tower. The crossing tower was not damaged. The area was experiencing winter storm conditions at the time of the outage. Detuning pendulums are installed on the north phase of this circuit. Galloping was reported by untrained observers with 6.4 mm - 12.7 mm (1/4-1/2 inch) of ice accumulation on the conductors. The temperature was at the freezing point with winds from the south-east at 30-40 kph (18.8-25 mph). All phases of both the river crossing span and the dead-end span on the Canadian side were estimated to be galloping at 9.1 m (30 ft) in two loops. A summary of the observation and a map of the test site are contained in Appendix III.

4.0 OBSERVATION AT ONTARIO HYDRO DISTRIBUTION TEST SITES

Clinton Area - Dashwood Junction

On December 14, 1985, modest galloping was observed at the Clinton Area - Dashwood Junction distribution test site. This site is part of a CEA sponsored project on distribution line galloping. The site covers 12 spans of a single circuit 27 kV line. Russian tee foils, air flow spoilers and detuning pendulums are installed at this site.

Movie films and written observations provide the details of this occurrence. The temperature was -1°C with the wind from the south-east at 51 kph (32 mph) gusting to 61 kph (38 mph). The ice thickness was estimated to be 3 mm (1/8 inch). The weather was overcast with rain. The pendulums were moving slightly at 10-15 cm (4-6 inches) and the tee foils at 30-35 cm (12-14 inches). The air flow spoilers and the reference phases were moving slightly but this appeared to be caused by bulk wind motion and not galloping. A summary of the observation and a map of the test site are contained in Appendix IV.

5.0 OBSERVATIONS AT OTHER CANADIAN TEST SITES

Nova Scotia - Cheticamp

On December 27, 1984, galloping was reported the Cheticamp test site in Nova Scotia. This site is also part of the CEA project on distribution line galloping. The site covers 10 spans of a single circuit 12 kV line. At the time the observation was taken, there were detuning pendulums and air flow spoilers installed.

The observation was made very early in the morning so darkness prevented movie films or detailed written observations to be made. The performance of the devices were mixed. On one span the air flow spoilers performed better. On another span the detuning pendulums appeared to work better. There was one span

where the phases with the devices both galloped while the reference phase remained still. No details on galloping amplitudes or loops were provided. It was also reported that it was difficult to form an opinion as to which device performed better. Details and a map of the test site are contained in Appendix V.

Saskatchewan Power Corp - SW8

An unusual vibration problem occurred at the SW8 distribution test site in Saskatchewan. Russian tee foils, detuning pendulums and air flow spoilers are installed at this site. On two different occasions one phase of one end span where aerodynamic drag dampers are installed was observed to cause vibration in the presence of wind but no ice. At the same time however, the reference phases as well as the phases with detuning pendulums and air flow spoilers were observed to be still. So severe was the vibration that the four weights of the two stockbridge dampers used to control aeolian vibration broke off. A twisting motion of the conductor of about 90° peak to peak was also observed. As a remedial action, the tee foils were removed from the problem span and the adjacent span. Movie film was taken of the vibration. Details of the two incidents and a map of the test site are contained in Appendix V.

6.0 OBSERVATIONS AT SITES IN THE UNITED STATES

During the 1984-1985 winter, there were six reported galloping occurrences at three American utilities.

City of Colorado Springs - Drake to Fairview

On December 13, 1984, galloping was observed on four spans of the Drake to Fairview single conductor line. This 115 kV, double circuit line runs in an east-west direction and has no galloping control devices installed.

Written records of the occurrence indicate there was about 9.5 mm (3/8 inch) of ice on the conductors. The temperature at the time of galloping was -5°C (23°F), the wind was southeasterly at 16 kph (10 mph) accompanied by freezing drizzle. All six phases of the four spans were observed to be galloping at 3.0-4.6 m (10-15 ft). The type of motions were not reported. A summary of this observation is contained in Appendix VI.

City of Colorado Springs - Cottonwood to Falcon

On January 9, 1985, galloping was observed on three spans of the Cottonwood to Falcon single conductor line. This 230 kV, double circuit line runs in an east-west direction and has no galloping control devices installed.

Written observations and 8 mm movie film were taken during the occurrence. The temperature was -9°C (16°F), the wind was from the north at 16 kph (10 mph) and the weather was dry. Ice deposits on the conductors had built up to about 25.4 mm (1.0 in). All six phases of the three observed spans were galloping at 2.1 m (7 ft) in one loop. A summary of this observation is contained in Appendix VI.

City of Colorado Springs - Cottonwood to Powers

Also on January 9, 1985, galloping was observed on four spans of the Cottonwood to Powers distribution line. This 34.5 kV, single circuit line runs in an east-west direction and has no galloping control devices installed.

Written observations and 8 mm movie film were taken during the occurrence. The temperature was -9°C (16°F), the wind was from the north at 16 kph (10 mph) and the weather was dry. There was about 25.4 mm (1.0 in) of ice on the conductors. All three phases of the four spans observed were galloping at 1.2 m (4 ft) with a mixture of one and two loops. A summary of this observation is contained in Appendix VI.

Nebraska Public Power District - Geneva to Carlton

On December 31, 1984, galloping was reported on two spans of the Geneva to Carlton single conductor line. This 115 kV, single circuit line runs in an east-west direction and there are no galloping control devices installed.

Written observations and VHS videotape were taken during the occurrence. The temperature was -12°C (10°F) and the wind was from the north at 9.7-20.9 kph (6-13 mph). The ice build-up on the conductors was not recorded. Galloping amplitudes ranged from 0.6-2.4 m (2-8 ft) in one loop. Some travelling wave motions were noted as well. A summary of this observation is contained in Appendix VI.

Commonwealth Edison - L11106

On December 31, 1984, galloping was observed on 16 spans of the L11106 single conductor line. This 138 kV, single circuit line runs in a north-south direction. Eight of the observed spans have Preformed air flow spoilers installed on all phases.

Written observations and VHS videotape were taken during the occurrence. The temperature was -1°C (30°F) and the wind was from the east at 16-24 kph (10-15 mph). An ice layer of 6.4 mm (0.25 in) had been deposited on the conductors. The galloping amplitudes on the untreated phases reached 1.4 m (4.5 ft) in one

loop. The phases with air flow spoilers had motions up to 0.6 m (2 ft) in two and three loops. A summary of this observation is contained in Appendix VI.

Commonwealth Edison - L15502

On January 1, 1985, galloping was observed on one span of the L15502 bundle line. This 345 kV, single circuit line runs in an east-west direction and there are no galloping control devices installed.

Written records are used to document this occurrence. The temperature was -6°C (21°F) and the wind was from the north at 16 kph (10 mph). The ice on the conductors was reported to be 3 mm (1/8 inch) thick. Galloping amplitudes were between 2.4-3.7 m (8-12 ft) in one loop. A summary of this occurrence is contained in Appendix VI.

7.0 CONCLUSIONS

Recorded observations of galloping occurrences on lines across Canada and the United States have been documented for the 1984-1985 winter season. As stated, this report does not attempt to interpret the observational data. The conclusions made in References 8, 9, 10 and 11 indicate that the air flow spoiler, the modified drag damper, the interphase spacer and the detuning pendulum show promise at reducing galloping amplitudes or preventing galloping altogether. The data presented in this report do not change these conclusions.

8.0 ACKNOWLEDGEMENTS

The author wishes to express his appreciation to the people who made the observations documented in this report.

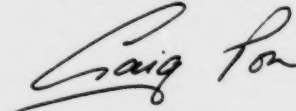
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Manager
Mechanical Research Dept

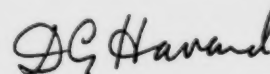
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APPENDIX I
OBSERVATIONS AT ONTARIO HYDRO SINGLE
CONDUCTOR TEST SITES

<u>DATE</u>	<u>TEST SITE</u>	<u>OBSERVATION NUMBER</u>
December 14, 1984	Manby Test Site	S55
December 14, 1984	Claireville TS x Richview TS Test Site	S56
December 14, 1984	Nanticoke GS x Middleport TS 230 kV Test Site	S57
January 7, 1985	Manby Test Site	S58
March 4, 1985	Burlington TS x Hamilton Beach TS Test Site	S59

DATA FROM FIELD OBSERVATIONS OF GALOPING
AT ONTARIO HYDRO SINGLE CONDUCTOR TEST SITES

OBSERVATION NO S55

PAGE: 1 of 2

DATE: Dec. 14, 1984

UTILITY: Ontario Hydro				SITE: Manby TS				VOLTAGE: 115 kV		LINE DIR'N: N-S			
CONDUCTOR NAME: ACSR				COND'R DIAMETER: 40.6 mm 1.6 in				COND'R CONST: 72/7					
CONDUCTOR SIZE: 1843.2 kcmil				COND'R WT. 2.952 kg/m 1.955 lb/ft				AREA OF ALUM: 934 mm ² 1.448 in ²					
NO OF SUBCONDUCTORS: 1				SUBCOND'R SPACING: - mm - in				AREA OF STEEL: 40.6 mm ² 0.063 in ²					
TENSION AT 0°C 26.4 kN 5100 lb				TORS'L STIFF: 855 Nm ² /r 2070 ft ² ·lb/r				ICE SHAPE, POSITION					
PENDULUM WT./SPAN: 56.4 kg 124 lb				NO OF LOCATIONS PER SPAN: 4									
PENDULUM ARM LENGTH: 119 mm 4.7 in and 48 mm 1.9 in				RADIUS OF GYRATION: 145 mm 5.7 in and 66 mm 2.6 in									
WEATHER: Rain & Freezing Rain				WIND SPEED: 4.5-6.7 m/s 10-15 mph									
TEMPERATURE: -1°C 30.2°F				WIND DIRECTION: East to West				ICE THICKNESS: 3 mm 0.125 in					
TIME	SPAN, TOWER NOs	SPAN LENGTH m ft	SAG m ft	GALLOPING AMPLITUDE: m ft								MAX'IM THEOR AMPL. m ft	PROT'N LEVEL
				NUMBER OF LOOPS									
				DET'D	DET'D	REF	REF	REF	REF	REF	REF		
				OEL *	OEM *	OEU *	IEL *	IEM *	IEU *	IWL *	IWM *		OEM OEL
3:45 pm to 4:45 pm	2-3	161 528	4.1 13.1	0 0 0	0 0 0	1.5 5 1	0.3 1 1	0.9 3 1	1.5 5 1	0.3 1 1	1.5 5 1	6.4 21.1	0.111 0.113
"	2-3					REF IWU*	REF OWL*	REF OWN*	REF OWU*				
"	2-3					2.4 8 1	0.3 1 1	1.5 5 1	2.4 8 1				
"	3-4	168 550	4.4 14.5	0 0 0	0.5 1.5 2	1.5 5 2	0.3 1 2	1.2 4 2	1.5 5 2	0.3 1 1	1.2 4 2	6.7 21.1	0.108 0.109
"	3-4					REF IWU*	REF OWL*	REF OWN*	REF OWU*				
"	3-4					1.5 5 2	0.3 1 2	1.2 4 2	1.5 5 2				
*PHASE LOCATION: N-North, S-South, E-East, W-West, U-Upper, M-Middle, L-Lower, I-Inner, O-Outer													

DATA FROM FIELD OBSERVATIONS OF GALLOPING
AT ONTARIO HYDRO SINGLE CONDUCTOR TEST SITES

OBSERVATION NO S55 (Cont'd)

PAGE: 2 of 2

DATE: Dec. 14, 1984

UTILITY: Ontario Hydro				SITE: Manby TS				VOLTAGE: 115 kV				LINE DIR'N: N-S	
CONDUCTOR NAME: ACSR				COND'R DIAMETER: 40.6 mm 1.6 in				COND'R CONST: 72/7					
CONDUCTOR SIZE: 1843.2 kcmil				COND'R WT. 2.952 kg/m 1.955 lb/ft				AREA OF ALUM: 934 mm ² 1.448 in ²					
NO OF SUBCONDUCTORS: 1				SUBCOND'R SPACING: - mm - in				AREA OF STEEL: 40.6 mm ² 0.063 in ²					
TENSION AT 0°C 26.4 kN 5100 lb				TORS'L STIFF: 855 Nm ² /r 2070 ft ² .lb/r				ICE SHAPE, POSITION					
PENDULUM WT./SPAN: 56.4 kg 124 lb				NO OF LOCATIONS PER SPAN: 4									
PENDULUM ARM LENGTH: 119 mm 4.7 in and 48 1.9				RADIUS OF GYRATION: 145 mm 5.7 in and 66 2.6									
WEATHER: Rain & Freezing Rain				WIND SPEED: 4.5-6.7 m/s 10-15 mph									
TEMPERATURE: -1°C 30.2°F				WIND DIRECTION: East to West				ICE THICKNESS: 3 mm 0.125 in					

TIME	SPAN, TOWER NOs	SPAN LENGTH m ft	SAG m ft	GALLOPING AMPLITUDE: m ft										MAX'M THEOR AMPL. m ft	PROT'N LEVEL
				NUMBER OF LOOPS											
				DET'D	DET'D	REF	REF	REF	REF	REF	REF	REF	REF		
				OEL *	OEM *	OEU *	IEL *	IBM *	IEU *	IWL *	IWM *				
3:45 pm to 4:45 pm	4-5	168	4.4	0	0.9	1.5	0	0.9	1.5	0.3	0.9	6.7	0.108		
		550	14.5	0	3	5	0	3	5	1	3	22.0	0.109		
				0	2	2	0	2	2	2					
"	4-5					REF	REF	REF	REF						
						IWU*	OWL*	OWN*	OWU*						
"	4-5					1.5	0	0.9	1.5						
						5	0	3	5						
						2	0	2	2						
"	5-6	165	4.3	0	0.9	1.5	0	0.9	1.5	0.3	0.9	6.6	0.109		
		540	14.0	0	3	5	0	3	5	1	3	21.6	0.111		
				0	2	2	0	2	2	2					
"	5-6					REF	REF	REF	REF						
						IWU*	OWL*	OWN*	OWU*						
"	5-6					1.5	0	0.9	1.5						
						5	0	3	5						
						2	0	2	2						

*PHASE LOCATION: N-North, S-South, E-East, W-West, U-Upper, M-Middle, L-Lower, I-Inner, O-Outer

GALLOPING REPORT**MANBY CIRCUITS**

115 kV, 1843.2 kmil (1.6")

1) INDICATE ON WHICH SPANS GALLOPING IS OCCURRING (X) AND NUMBER OF LOOPS PER SPAN

2) INDICATE WHETHER IT IS:

LOWER PHASE (L)
CENTRE PHASE (C)
UPPER PHASE (U)
OR ALL PHASES (A)

3) SHOW WIND DIRECTION (→)

4) WIND SPEED:

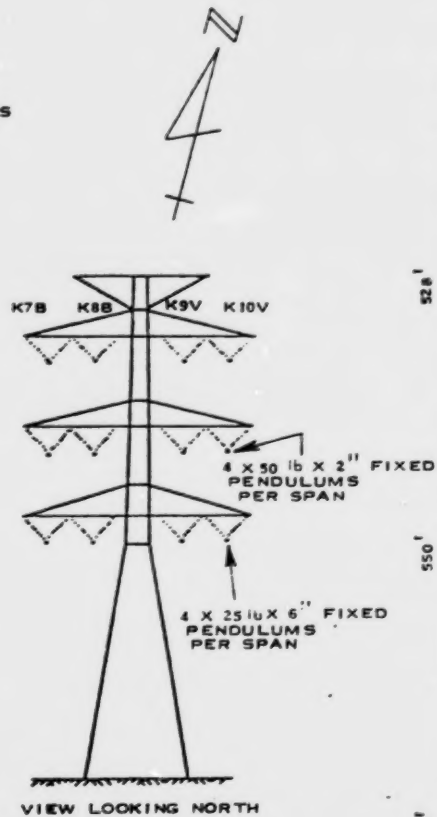
0 - 5mph
5 - 15mph
15 - 25mph
25 - 35mph

5) APPROXIMATE ICE THICKNESS ON METAL OBJECTS INCHES

6) MOVING FILM MADE: YES
NO

7) COMMENTS:

● FIXED PENDULUM

**MANBY TS**

TOWER 2	
528'	4/5
	2/3
	5/12
	1/4
550'	1/4
	5/12
	2/3
	4/5
550'	1/4
	5/12
	2/3
	4/5
340'	1/4
	5/12
	2/3
	4/5

NORTH QUEEN ST

MANBY CIRCUITS

8) PLEASE CALL:

D.G. HAVARD - (416) 279-3212 (HOME)
OR LOCAL 122-8717

DATE:

TIME:

OBSERVED BY:

DATA FROM FIELD OBSERVATIONS OF GALLOPING
AT ONTARIO HYDRO SINGLE CONDUCTOR TEST SITES

OBSERVATION NO S56

PAGE: 1 of 1

DATE: Dec. 14/84

UTILITY: Ontario Hydro				SITE: Clatreville TS x Richview TS				VOLTAGE: 230 kV				LINE DIR'N: N-S	
CONDUCTOR NAME: ACSR				COND'R DIAMETER: 46 mm 1.8 in				COND'R CONST: 72/19					
CONDUCTOR SIZE: 2332.8 kcmil				COND'R WT. 3.69 kg/m 2.47 lb/ft				AREA OF ALUM: 1182 mm ² 1.832 in ²					
NO OF SUBCONDUCTORS: 1				SUBCOND'R SPACING: - mm - in				AREA OF STEEL: 50 mm ² 0.070 in ²					
TENSION AT 0°C 46.5 kN 10492 lb				TORS'L STIFF: 1446 Nm ² /r 3500 ft ² ·lb/r						ICE SHAPE, POSITION			
PENDULUM WT./SPAN: 52.3 kg 115 lb and 91 kg 200 lb				NO OF LOCATIONS PER SPAN: 3 and 4									
PENDULUM ARM LENGTH: 234 mm 9.2 in 447 17.6				RADIUS OF GYRATION: 213 mm 8.4 in 434 17.1									
WEATHER: Wet Drizzle				WIND SPEED: 4.5-6.3 m/s 10-14 mph									
TEMPERATURE: 0°C 32 °F				WIND DIRECTION: East to West						ICE THICKNESS: 1.6 mm 0.06 in			
TIME	SPAN, TOWER NOs	SPAN LENGTH m ft	SAG m ft	GALLOPING AMPLITUDE: m ft								MAX'IM THEOR AMPL. m ft	PROT'N LEVEL
				NUMBER OF LOOPS									
				DET'D	DET'D	EPD	REF	REF	REF	REF	REF		
				V72RL *	V72RM*	V72RU*	V71RL*	V71RM*	V71RU*	V73RL*	V73RM*		V72RL
													V72RM
3:45 pm	68-69	265	6.8	0	0	0	0	0	0	0	0	9.1	0.14
				0	0	0	0	0	0	0	0		
		870	22.3	0	0	0	0	0	0	0	0	29.8	0.13
	69-70	254	6.2	0	0	0	0	0	0	0	0	8.1	0.14
				0	0	0	0	0	0	0	0		
		833	20.4	0	0	0	0	0	0	0	0	26.7	0.13
				REF	REF	REF	REF	REF	REF	REF			
				V73RU	V74RL	V74RM	V74RU	V75RL	V75RM	V75RV			
	68-69	265	6.8	NA**	0	0	0	0	0	0		9.1	
				NA	0	0	0	0	0	0			
		870	22.3	1	0	0	0	0	0	0		29.8	
	69-70	254	6.2	1.5	0	0	NA**	0	0	0		8.1	
				5	0	0	NA	0	0	0			
		833	20.4	182	0	0	1	0	0	0		26.7	
*PHASE LOCATION: N-North, S-South, E-East, W-West, U-Upper, M-Middle, L-Lower, I-Inner, O-Outer													
** There were definite motions but amplitudes were small and were not recorded.													

DATA FROM FIELD OBSERVATIONS OF GALLOPING
AT ONTARIO HYDRO SINGLE CONDUCTOR TEST SITES

OBSERVATION NO S57

PAGE: 1 of 1

DATE: Dec. 14/84

UTILITY: Ontario Hydro				SITE: Nanticoke GS x Middleport TS				VOLTAGE: 230 kV				LINE DIR'N: N-S	
CONDUCTOR NAME: ACSR				COND'R DIAMETER: 40.6 mm 1.6 in				COND'R CONST: 72/7					
CONDUCTOR SIZE: 1843 kcmil				COND'R WT. 2.952 kg/m 1.95 lb/ft				AREA OF ALUM: 934 mm ² 1.4477 in ²					
NO OF SUBCONDUCTORS: 1				SUBCOND'R SPACING: - mm - in				AREA OF STEEL: 40.6 mm ² 0.0625 in ²					
TENSION AT 0°C 37 kN 8138 lb				TORS'L STIFF: 985 Nm ² /r 2383 ft ² ·lb/r				ICE SHAPE, POSITION					
PENDULUM WT./SPAN: 125 kg 274 lb				NO OF LOCATIONS PER SPAN: 4									
PENDULUM ARM LENGTH: 119 mm 4.7 in				RADIUS OF GYRATION: 145 mm 5.7 in									
WEATHER: Fine Rain				WIND SPEED: 3.6 m/s 8 mph									
TEMPERATURE: 0°C 32°F				WIND DIRECTION: from North-East				ICE THICKNESS: 3.2 mm 0.125 in					

TIME	SPAN, TOWER NOs	SPAN LENGTH m ft	SAG m ft	GALLOPING AMPLITUDE: NUMBER OF LOOPS								MAX'N THEOR AMPL. m ft	PROT'N LEVEL	
				DET'D	REF	REF	REF	REF	REF	REF	REF			
				EM *	EL *	EU *	WL *	WM *	WU *	*	*			
2:40 pm	43-44	228	5.1	1.2	0	0	0	0	0	0			3.7	0.124
		748	16.7	4	0	0	0	0	0	0				

*PHASE LOCATION: N-North, S-South, E-East, W-West, U-Upper, M-Middle, L-Lower, I-Inner, O-Outer

GALLOPING REPORT

ENV LINE; 4 X 3854cmH X 20" SQ. BUNDLE
NANTICOKE TO MIDDLEPORT

- 2 INDICATE ON WHICH SPANS GALLOPING
IS OCCURRING (X)

- 2) SHOW WIND DIRECTION FOR EACH LINE SECTION ()

- 20 WIND SPEED:

0 - 5 mph
5 - 15 mph
15 - 25 mph
25 - 35 mph
ABOVE 35 mph

- 4 APPROXIMATE ICE THICKNESS ON METAL OBJECTS INCHES

- ## 9 GALLOPING MODE

WEST PHASE.....LOOP
CENTRE PHASE.....LOOP
EAST PHASE.....LOOP

- #### 4. FREQUENCY

WEST PHASE. H8
CENTRE PHASE H8
EAST PHASE. H8

- 7) MOVING FILM MADE: YES
NO

- COMMENTS:**

- - FIXED PENDULUMS
- ! - MOD. DRAG DAMPER

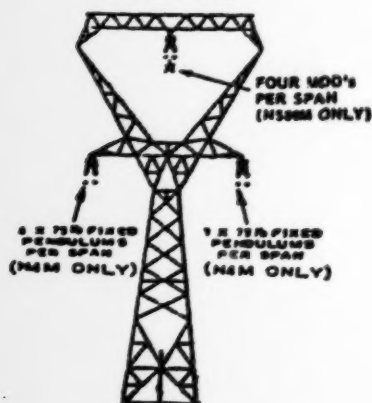
- PLEASE CALL**

D. G. HAVARD
'415) 375-3212 (HOME)
OR LOCAL 122-5717

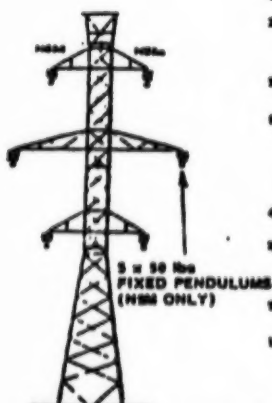
DATE:

TIME:

OBSERVED BY:



WOMAN LOOKING HEAVY
FROWN, 1944



**VIEW LOUNGE
WITH THE
TOWN, 1990**

[illegible]

DATA FROM FIELD OBSERVATIONS OF GALLOPING
AT ONTARIO HYDRO SINGLE CONDUCTOR TEST SITES

OBSERVATION NO 558

PAGE: 1 of 1

DATE: Jan. 7/85

UTILITY: Ontario Hydro				SITE: Manby TS				VOLTAGE: 115 kV				LINE DIR'N: N-S			
CONDUCTOR NAME: ACSR				COND'R DIAMETER: 40.6 mm 1.6 in				COND'R CONST: 72/7							
CONDUCTOR SIZE: 1842.3 kcmil				COND'R WT. 2.952 kg/m 1.955 lb/ft				AREA OF ALUM: 934 mm ² 1.448 in ²							
NO OF SUBCONDUCTORS: 1				SUBCOND'R SPACING: - mm - in				AREA OF STEEL: 40.6 mm ² 0.063 in ²							
TENSION AT 0°C 26.4 kN 5100 lb				TORS'L STIFF: 855 Nm ² /r 2070 ft ² ·lb/r				ICE SHAPE, POSITION							
PENDULUM WT./SPAN: 56.4 kg 124 lb				NO OF LOCATIONS PER SPAN: 4											
PENDULUM ARM LENGTH: 119 m 4.7 in 48 m 1.9 in				RADIUS OF GYRATION: 145 mm 5.7 in 66 mm 2.6 in											
WEATHER: overcast				WIND SPEED: 1.8-4.0 m/s 4.9 mph											
TEMPERATURE: -7°C 19.4°F				WIND DIRECTION: from NNE				ICE THICKNESS: 10-20 mm 0.4-0.8 in							

TIME	SPAN, TOWER NOs	SPAN LENGTH m ft	SAG m ft	GALLOPING AMPLITUDE: m ft									MAX'IM THEOR AMPL. m ft	PROT'N LEVEL OEM OEL
				NUMBER OF LOOPS										
				DET'D	DET'D	REF	REF	REF	REF	REF	REF	REF		
				OEL *	OEM *	IEL *	IWL *	OWL *	IEL *	IWL *	OWL *			
11:50 am	3-4	168	4.4	0	0	1.6	1.6	1.6				6.7	0.111	
		550	14.5	0	0	5.1	5.1	5.1				21.1	0.113	
				0	0	1	1	1						
1:00 pm	3-4			0	0	0	0	0	galloping stopped					
				0	0	0	0	0						
				0	0	0	0	0						
2:50 pm	3-4			0	0	2.1	2.1	2.1	1.0	1.0	1.0			
				0	0	6.8	6.8	6.8	3.4	3.4	3.4			
				0	0	1	1	1	1	1	1			
				<u>REF</u>	<u>REF</u>	<u>REF</u>								
				IEL	IWL	OWL								
11:50 am to 2:50 pm	3-4	168 550	4.4 14.5	0 0 0	0 0 0	0 0 0								

*PHASE LOCATION: N-North, S-South, E-East, W-West, U-Upper, M-Middle, L-Lower, I-Inner, O-Outer

DATA FROM FIELD OBSERVATIONS OF GALLOPING
AT ONTARIO HYDRO SINGLE CONDUCTOR TEST SITES

OBSERVATION NO S59

PAGE: 1 of 1

DATE: Mar. 4/85

UTILITY: Ontario Hydro				SITE: Burlington TS x Hamilton Beach TS				VOLTAGE: 230 kV		LINE DIR'N: N-S	
CONDUCTOR NAME: Grackle				COND'R DIAMETER: 35 mm 1.388 in				COND'R CONST: 54/19			
CONDUCTOR SIZE: 1192.5 kcmil				COND'R WT. 2.227 kg/m 1.526 lb/ft				AREA OF ALUM: 6.4 mm ² 0.9367 in ²			
NO OF SUBCONDUCTORS: 1				SUBCOND'R SPACING: - mm - in				AREA OF STEEL: 76 mm ² 0.118 in ²			
TENSION AT 0°C 26.4 kN 5940 lb				TORS'L STIFF: 413 Nm ² /r 1000 ft ² ·lb/r				ICE SHAPE, POSITION			
PENDULUM WT./SPAN: 42 kg 93 lb 56 124				NO OF LOCATIONS PER SPAN: 3/4							
PENDULUM ARM LENGTH: 119 mm 4.7 in				RADIUS OF GYRATION: 145 mm 5.7 in							
WEATHER: N/A				WIND SPEED: 11.2-15.6 m/s 25-35 mph							
TEMPERATURE: -2°C °F				WIND DIRECTION: east to west				ICE THICKNESS: 3.2 mm 0.125 in			

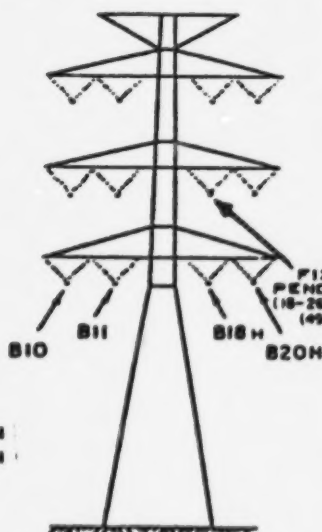
TIME	SPAN, TOWER NOs	SPAN LENGTH m ft	SAG m ft	GALLOPING AMPLITUDE:								MAX'IM THEOR AMPL. m ft	PROT'N LEVEL
				NUMBER OF LOOPS									
				DET'D	REF	REF	REF	REF	REF	REF	REF		
				EIM *	EIU *	EIL *	EOU *	EOI *	EOL *	WIU *	WIM *		
11:45 am	47-48 dead ended	231 758	5.6 18.5	0.6 2 2	0.9 3 2	0.9 3 2	0.9 3 2	0.9 3 2	0.9 3 2	0.9 3 2	0.9 3 2	3.9 12.9	0.074
	48-49 dead ended	233 766	5.7 18.8	0.6 2 2	1.2 4 2	1.2 4 2	1.2 4 2	1.2 4 2	1.2 4 2	1.2 4 2	1.2 4 2	4.0 13.0	0.083
	49B-50 dead ended	192 629	3.5 11.6	1.8 6 2	0 0 0	0 0 0						3.6 11.8	0.096
				REF WIL *	REF WOU *	REF WOM *	REF WOL *						
	47-48	231 758	5.6 18.5	0.9 3 2	0.9 3 2	0.9 3 2	0.9 3 2						
	48-49	233 766	5.7 18.8	1.2 4 2	1.2 4 2	1.2 4 2	1.2 4 2						

*PHASE LOCATION: N-North, S-South, E-East, W-West, U-Upper, M-Middle, L-Lower, I-Inner, O-Outer

GALLOPING REPORT

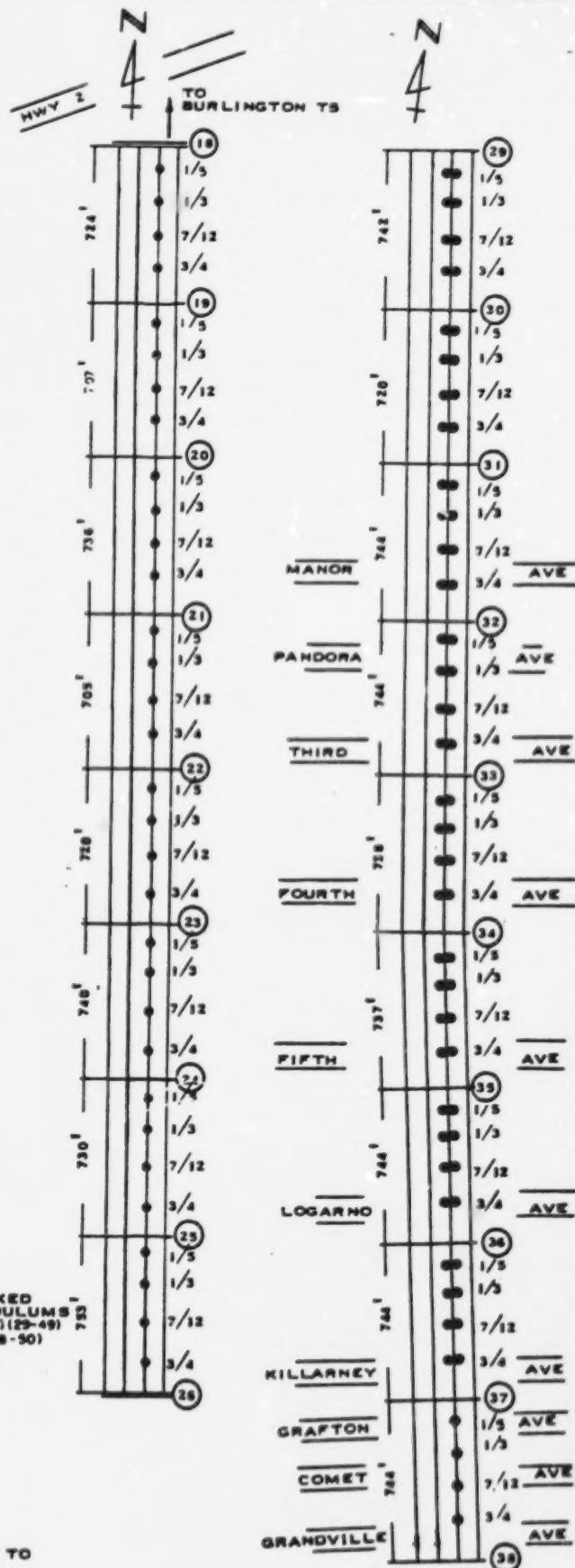
BURLINGTON - HAMILTON BEACH
230 kv, 1192 kcmil (1,338¹¹)

- 1) INDICATE WHICH SPANS GALLOPING IS OCCURRING (X) AND NO. OF LOOPS PER SPAN
- 2) INDICATE WHETHER IT IS:
- LOWER PHASE (L)
CENTRE PHASE (C)
UPPER PHASE (U)
OR ALL PHASES (A)
- 3) SHOW WIND DIRECTION FOR EACH LINE SECTION ()
- 4) WIND SPEED:
- 0 - 5 mph
5 - 15 mph
15 - 25 mph
25 - 35 mph
ABOVE 35 mph
- 5) APPROXIMATE ICE THICKNESS ON METAL OBJECTS INCHES
- 6) MOVING FILM MADE: YES
NO
- 7) COMMENTS:



- - 25 lb. FIXED PENDULUM
- - 50 lb. FIXED PENDULUM

LOOKING FROM HAMILTON BEACH TS TO
BURLINGTON TS (TOWERS 1 THRU 49)



GALLOPING REPORT

(BURLINGTON - HAMILTON BEACH)

1) INDICATE ON WHICH SPANS
GALLOPING IS OCCURRING (X)

2) INDICATE WHETHER IT IS:
LOWER PHASE (L)
CENTRE PHASE (C)
UPPER PHASE (U)
OR ALL PHASES (A)

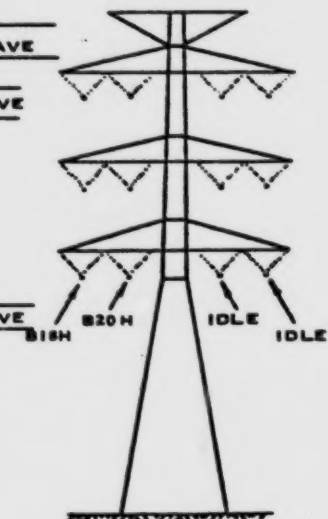
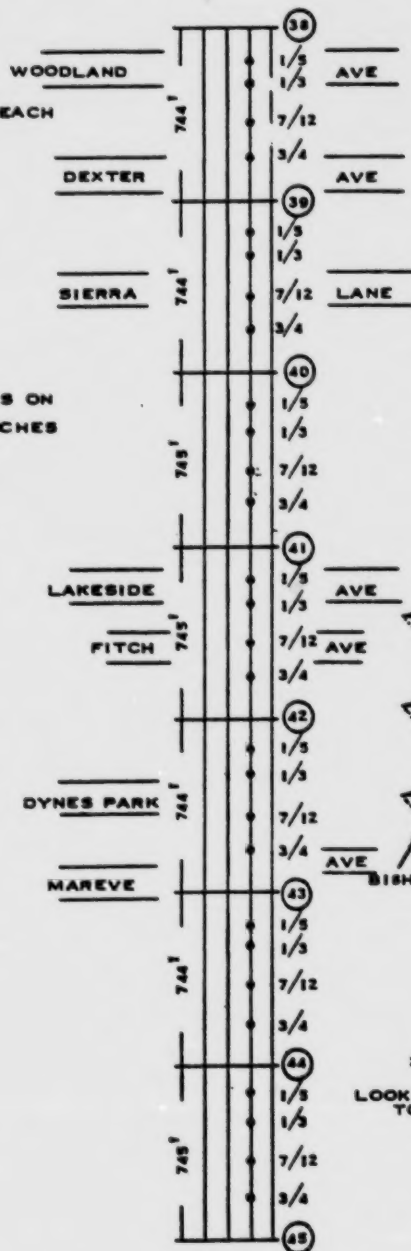
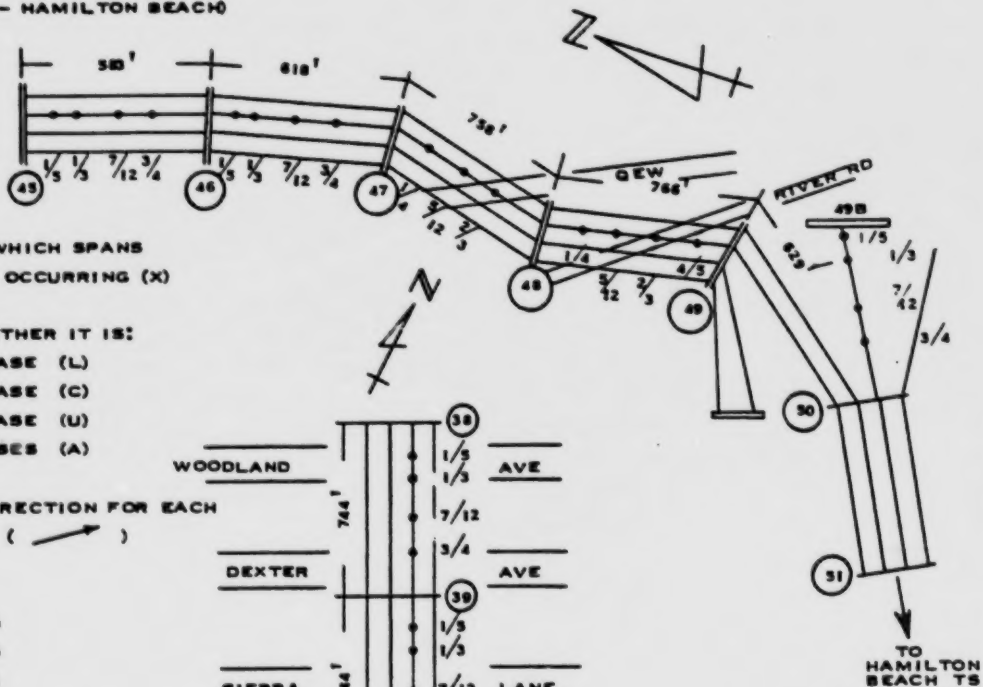
3) SHOW WIND DIRECTION FOR EACH
LINE SECTION (→)

4) WIND SPEED:
0 - 5 mph
5 - 15 mph
15 - 25 mph
25 - 35 mph
ABOVE 35 mph

5) APPROXIMATE ICE THICKNESS ON
METAL OBJECTS INCHES

6) MOVING FILM MADE: YES
NO

7) COMMENTS:



LOOKING FROM HAMILTON TS
TOWERS 30 TO 37

23 -

85-276

8) PLEASE CALL:

D. G. HAVARD - (416) 279-3212 (HOME)
OR LOCAL 122-5717

DATE:

TIME:

RECEIVED BY:

APPENDIX II

OBSERVATIONS AT OTHER ONTARIO HYDRO
SINGLE CONDUCTOR SITES

<u>DATE</u>	<u>SITE</u>
December 14, 1984	Burlington TS x Hamilton Beach TS
December 14, 1984	Allanburg TS

DATA FROM FIELD OBSERVATIONS OF GALLOPING
AT ONTARIO HYDRO SINGLE CONDUCTOR TEST SITES

OBSERVATION NO .

PAGE: 1 of 1

DATE: Dec. 14/85

UTILITY: Ontario Hydro				SITE: Burlington TS x Hamilton Beach TS				VOLTAGE: 230 kV		LINE DIR'N: NE-SW	
CONDUCTOR NAME: Grackle				COND'R DIAMETER: 35 mm 3.388 in				COND'R CONST: 54/19			
CONDUCTOR SIZE: 1192.5 kcmil				COND'R WT. 2.227 kg/m 1.526 lb/ft				AREA OF ALUM: 604 mm ² 0.9367 in ²			
NO OF SUBCONDUCTORS: 1				SUBCOND'R SPACING: - mm - in				AREA OF STEEL: 76 mm ² 0.118 in ²			
TENSION AT 0°C 26.4 kN 5940 lb				TORS'L STIFF: 413 Nm ² /r 1000 ft ² .lb/r				ICE SHAPE, POSITION			
PENDULUM WT./SPAN: - kg - lb				NO OF LOCATIONS PER SPAN: -							
PENDULUM ARM LENGTH: -mm - in				RADIUS OF GYRATION: - mm - in							
WEATHER: Sleet				WIND SPEED: 8.9-22.4 m/s 20-50 mph							
TEMPERATURE: 0°C 32°F				WIND DIRECTION: east to west				ICE THICKNESS: 3.2 mm 0.125 in			

TIME	SPAN, TOWER NOs	SPAN LENGTH m ft	SAG m ft	GALLOPING AMPLITUDE: m ft								MAX'M THEOR AMPL. m ft	PROT'N LEVEL
				NUMBER OF LOOPS									
				REF	REF	REF	REF	REF	REF	REF	REF		
				B10-U*	B10-M*	B10-L*	B11-U*	B11-M*	B11-L*	*	*	**	
2:00-		192	3.9	2.7	2.7	2.7	2.7	2.7	2.7			11.3	
2:45 pm	49-50	629	12.7	9	9	9	9	9	9			3.5	-

*PHASE LOCATION: N-North, S-South, E-East, W-West, U-Upper, M-Middle, L-Lower, I-Inner, O-Outer

**Deadend towers used in calculation

DATA FROM FIELD OBSERVATIONS OF GALLOPING
AT ONTARIO HYDRO SINGLE CONDUCTOR TEST SITES

OBSERVATION NO

PAGE: 1 of 1

DATE: Dec. 14, 1984

UTILITY: Ontario Hydro		SITE: Allanburg TS		VOLTAGE: 230 kV		LINE DIR'N: N-S	
CONDUCTOR NAME: Grackle		COND'R DIAMETER: 35 mm 1.333 in		COND'R CONST: 54/19			
CONDUCTOR SIZE: 1192.5 kcmil		COND'R WT 2.227 kg/m 1.533 lb/ft		AREA OF ALUM: 604 mm ² 0.9367 in ²			
NO OF SUBCONDUCTORS: 1		SUBCOND'R SPACING: - mm - in		AREA OF STEEL: 76 mm ² 0.118 in ²			
TENSION AT 0°C 29.7 kN 6663 lb 36.9 kN 8282 lb		TORS'L STIFF: 413 Nm ² /r 1000 ft ² ·lb/r				ICE SHAPE, POSITION	
PENDULUM WT./SPAN: - kg - lb		NO OF LOCATIONS PER SPAN: -					
PENDULUM ARM LENGTH: -mm - in		RADIUS OF GYRATION: - mm - in					
WEATHER: Freezing Rain		WIND SPEED: 8.9 m/s 20 mph					
TEMPERATURE: 0°C 32°F		WIND DIRECTION: NE to SW		ICE THICKNESS: 1.6 mm 0.63 in			

TIME	CIRCUIT TOWER NOs	SPAN LENGTH m ft	SAG m ft	GALLOPING AMPLITUDE: m ft								MAX'IM THEOR AMPL. m ft	PROT'N LEVEL
				NUMBER OF LOOPS									
				REF	REF	REF	REF	REF	REF	REF	REF		
				EU *	EM *	EL *	WU *	WM *	WL *	*	*		
1:30 pm	Q26A & Q28A 10-11	317 1040	7.6 25	4.6 15 2	4.6 15 2	4.6 15 2	4.6 15 2	4.6 15 2	4.6 15 2			8.4 - 27.6	-
2:00 pm	Q30A & Q32A 56-57	290 950	7.9 26	3.7 12 2	3.7 12 2	3.7 12 2	3.7 12 2	3.7 12 2	3.7 12 2			8.0 - 26.1	-

*PHASE LOCATION: N-North, S-South, E-East, W-West, U-Upper, M-Middle, L-Lower, I-Inner, O-Outer

**Semi-suspension towers used in calculation. Insulator length 7.5 ft.

APPENDIX III

OBSERVATION AT ONTARIO HYDRO BUNDLE
CONDUCTOR TEST SITES

<u>DATE</u>	<u>TEST SITE</u>	<u>OBSERVATION NUMBER</u>
December 14, 1984	Milton TS x Trafalgar TS Test Site	B31
March 4, 1985	Lambton GS x St. Clair River Jct (USA)	B32

DATA FROM FIELD OBSERVATIONS OF GALLOPING
AT ONTARIO HYDRO BUNDLE CONDUCTOR TEST SITES

OBSERVATION NO 831

PAGE: 1 of 1

DATE: Dec. 14/85

UTILITY: Ontario Hydro				SITE: Milton TS x Trafalgar TS				VOLTAGE: 500 kV				LINE DIR'N: N-S	
CONDUCTOR NAME: ACSR				COND'R DIAMETER: 24 mm 0.45 in				COND'R CONST: 26/7					
CONDUCTOR SIZE: 585 kcmil				COND'R WT. 120 kg/m 0.803 lb/ft				AREA OF ALUM: 296.5 mm ² 0.46 in ²					
NO OF SUBCONDUCTORS: 4				SUBCOND'R SPACING: 508 mm 20 in				AREA OF STEEL: 48.2 mm ² 0.075 in ²					
TENSION AT 0°C 27.3 kN 6170 lb				TORS'L STIFF: 165 Nm ² /r 400 ft ² ·lb/r				ICE SHAPE, POSITION					
PENDULUM WT./SPAN: 138 kg 303 lb 276 607 Incl. spacer-dampers				NO OF LOCATIONS PER SPAN: 4									
PENDULUM ARM LENGTH: 236 mm 9.27 in				RADIUS OF GYRATION: 295 mm 11.60 in									
WEATHER: Ice rain				WIND SPEED: 2.2-8.9 m/s 5-20 mph									
TEMPERATURE: -1°C 30.2°F				WIND DIRECTION: SE to NW				ICE THICKNESS: 3.2 mm 0.125 in					

TIME	SPAN, TOWER NOs	SPAN LENGTH m ft	SAG m ft	GALLOPING AMPLITUDE: m ft								MAX'M THEOR AMPL. m ft	PROT'N LEVEL
				NUMBER OF LOOPS									
				DET'D	REF	REF	REF	REF	REF	REF	REF		
				EL *	EM *	EU *	WL *	WM *	WU *	*	*		
1:40 pm	24-28	246 to 277 806 to 910		0 0 0	1.8 6 2	1.8 6 2	1.8 6 2	1.8 6 2	1.8 6 2			-	0.12 to 0.124
	36-40	233 to 274 765 to 900		0 0 0	1.8 6 2	1.8 6 2	1.8 6 2	1.8 6 2	1.8 6 2			-	0.089 to 0.101

*PHASE LOCATION: N-North, S-South, E-East, W-West, U-Upper, M-Middle, L-Lower, I-Inner, O-Outer

1) Indicate on which spans galloping is occurring (x) and number of loops per span

2) Indicate whether it is:

Lower phase (L)
Centre phase (C)
Upper phase (U)
or all phases (A)

3) Show wind direction for each line section ()

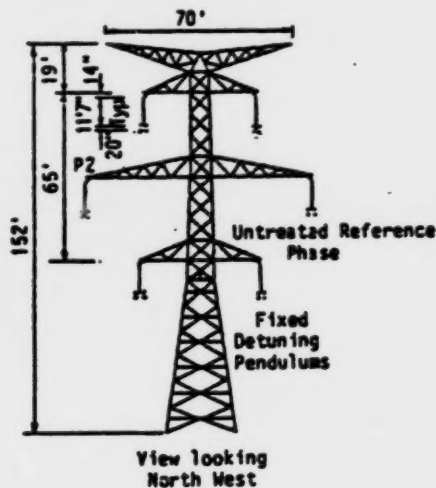
4) Wind speed:

0 - 5 mph
5 - 15 mph
15 - 25 mph
25 - 35 mph
above 35 mph

5) Approximate ice thickness on metal objects.....inches

6) Comments:

- - 4 x 25 lb Pendulums on Two Spacer-Dampers
- - 2 x 25 lb Fixed Pendulums



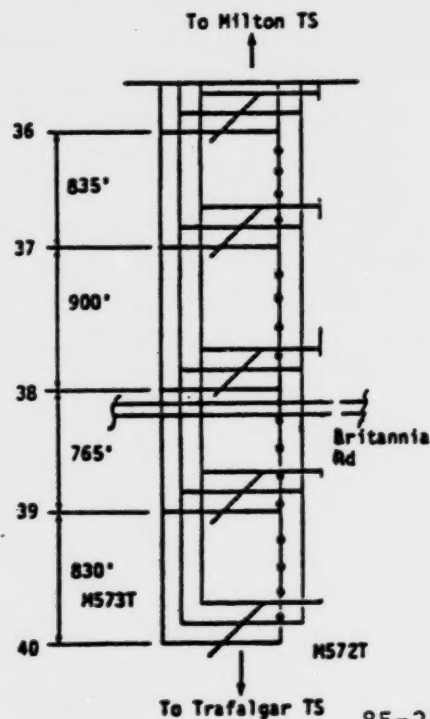
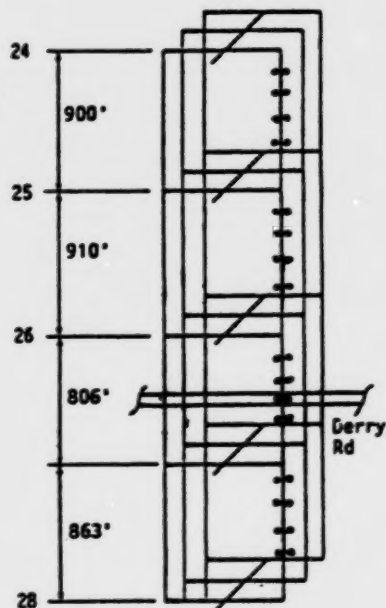
7) Moving film made: Yes
No

8) Please call:
D.G. Havard
(416) 279-3212 (home)
or local 122-6717

Date:

Time:

Observed by:



DATA FROM FIELD OBSERVATIONS OF GALLOPING
AT ONTARIO HYDRO BUNDLE CONDUCTOR TEST SITES

OBSERVATION NO 832

PAGE: 1 of 1

DATE: Mar. 4, 1985

UTILITY: Ontario Hydro				SITE: Lambton GS x St. Clair River Jct				VOLTAGE: 230 kV		LINE DIR'N: E-W	
CONDUCTOR NAME: Grackle				COND'R DIAMETER: 50.3 mm 2.0 in				COND'R CONST: 84/19			
CONDUCTOR SIZE: 1192.5 kcmil				COND'R WT 4.79 kg/m 3.21 lb/ft				AREA OF ALUM: 1407 mm ² 2.1803 in ²			
NO OF SUBCONDUCTORS: 2				SUBCOND'R SPACING: 559 mm 22 in				AREA OF STEEL: 114.6 mm ² 0.1776 in ²			
TENSION AT 0°C PER SUBCONDUCTOR: 72.55 kN 16310 lb				TORS'L STIFF: Nm ² /r 3500 ft ² .lb/r				ICE SHAPE, POSITION			
PENDULUM WT./SPAN: 136.4 kg 300 lb and 68.2 kg 150 lb				NO OF LOCATIONS PER SPAN: 8 and 4							
PENDULUM ARM LENGTH: 229 mm 9 in				RADIUS OF GYRATION: 229 mm 9 in							
WEATHER: Freezing Rain				WIND SPEED: 8.4-11.2 m/s 18.8-25 mph							
TEMPERATURE: 0°C 32°F				WIND DIRECTION: SE to NW				ICE THICKNESS: 6.4-12.7 mm 0.25-0.5 in			

TIME	SPAN TOWER NOs	SPAN LENGTH m ft	SAG m ft	GALLOPING AMPLITUDE: m ft								MAX'M THEOR AMPL. m ft	PROT'N LEVEL	
				NUMBER OF LOOPS										
				DET	REF	REF	REF	REF	REF	REF	REF			
				N *	M *	S *	*	*	*	*	*	*		
12:00 noon	River X-ing	665 2181	35.7 117	9.1 30 2	9.1 30 2	9.1 30 2							-	-
12:00 noon	Dead End	322 1056	8.4 27	9.1 30 2	9.1 30 2	9.1 30 2							-	-

NOTES: This site is known to be undertreated.
 Observation was made by untrained observers.
 River X-ing span was 8 x 37.5 lb stockbridge dampers acting as detuning pendulums.
 Dead end span has 4 x 37.5 lb stockbridge dampers acting as detuning pendulums.

*PHASE LOCATION: N-North, S-South, E-East, W-West, U-Upper, M-Middle, L-Lower, I-Inner, O-Outer

CEA**BUNDLE LINE GALLOPING
OBSERVATION DATA SHEET**

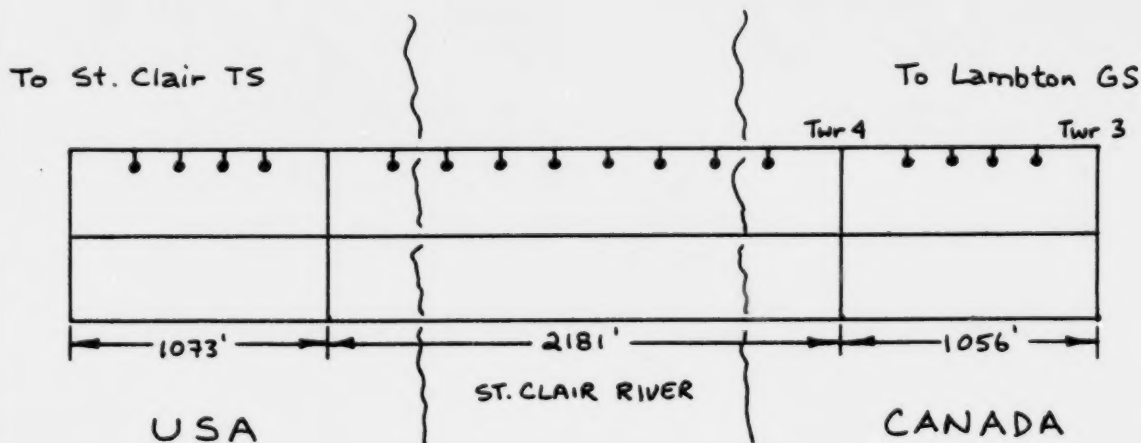
Utility Name: ONTARIO HYDRO
 Test Site Name: LAMBTON GS X ST. CLAIR RIVER JCT
 Date of Observation: MARCH 4, 1985
 Observed by: LEN H.
 No. of Subconductors: 2
 Subconductor Size: 1192.5 kcmil - Grackle
 Wind Speed: 8.4-11.2 m/sec (18.8-25 mph)
 Wind Direction: from SE to NW
 Air Temperature: 0°C (32°F)
 Ice Thickness (est'd): 6.4-12.7 mm (1/4 - 1/2 inch)
 General Weather Conditions: Freezing Rain

Please provide Test Site Map

- Indicate: 1) Wind Direction (✓)
 2) Which Spans Galloping (X)



Legend: • Stockbridge damper
 acting as detuning
 pendulum



Return completed form to: C.J. Pon
 Ontario Hydro Research Division
 800 Kipling Avenue, KR284
 Toronto, Ontario M8Z 5S4

APPENDIX IV

OBSERVATION AT ONTARIO HYDRO DISTRIBUTION
TEST SITES

<u>DATE</u>	<u>TEST SITE</u>	<u>OBSERVATION NUMBER</u>
December 14, 1984	Clinton Area - Dashwood Junction	S60

DATA FROM FIELD OBSERVATIONS OF GALLOPING
AT ONTARIO HYDRO SINGLE CONDUCTOR TEST SITES

OBSERVATION NO S60

PAGE: 1 of 1

DATE: Dec. 14/84

UTILITY: Ontario Hydro				SITE: Clinton Area - Dashwood Junction				VOLTAGE: 27 kV		LINE DIR'N: N-S	
CONDUCTOR NAME: ACS-Dahila				COND'R DIAMETER: 21.7 mm 0.856 in				COND'R CONST: 19			
CONDUCTOR SIZE: 556.5 kcmil				COND'R WT. 0.774 kg/m 0.522 lb/ft				AREA OF ALUM: mm ² 0.4371 in ²			
NO OF SUBCONDUCTORS: 1				SUBCOND'R SPACING: - mm - in				AREA OF STEEL: - mm ² - in ²			
TENSION AT 0°C 4.6 kN 1028 lb				TORS'L STIFF: 62 Nm ² /r 150 ft ² ·lb/r				ICE SHAPE, POSITION			
NO OF SPOILERS/SPAN: 4				NO OF COIL/SPAN: 14							
PENDULUM WT./SPAN: 11.4 kg 25 lb				NO OF LOCATIONS PER SPAN: 2							
PENDULUM ARM LENGTH: 282 mm 11.1 in				RADIUS OF GYRATION: 302 mm 11.9 in							
WEATHER: Overcast & rain				WIND SPEED: 14.3 m/s 32 mph							
TEMPERATURE: -1°C 30.2°F				WIND DIRECTION: SE to NW				ICE THICKNESS: 3.2 mm 0.125 in			

TIME	SPAN, TOWER NOs	SPAN LENGTH m ft	SAG m ft	GALLOPING AMPLITUDE: m ft								MAX'M THEOR AMPL. m ft	PROT'N LEVEL
				NUMBER OF LOOPS									
				DET'D	AFS	REF	RTF	REF	REF	REF	REF		
				E *	E *	M *	M *	W *	*	*	*		
12:00 noon	1-3	68-69 223 to 226	1.1 3.5	0.1-.15 0.3-0.5 1	-	0 0 0	-	0 0 0				1.7 5.6	0.15
	4-6			0.1-.15 0.3-0.5 1	-	-	0.3-0.5 1.0-1.2 -	0 0 0					
	7-9			-	0 0 0	-	0.3-.35 1.0-1.2 -	0 0 0					
	10-12			-	0 0 0	0 0 0	-	0 0 0					

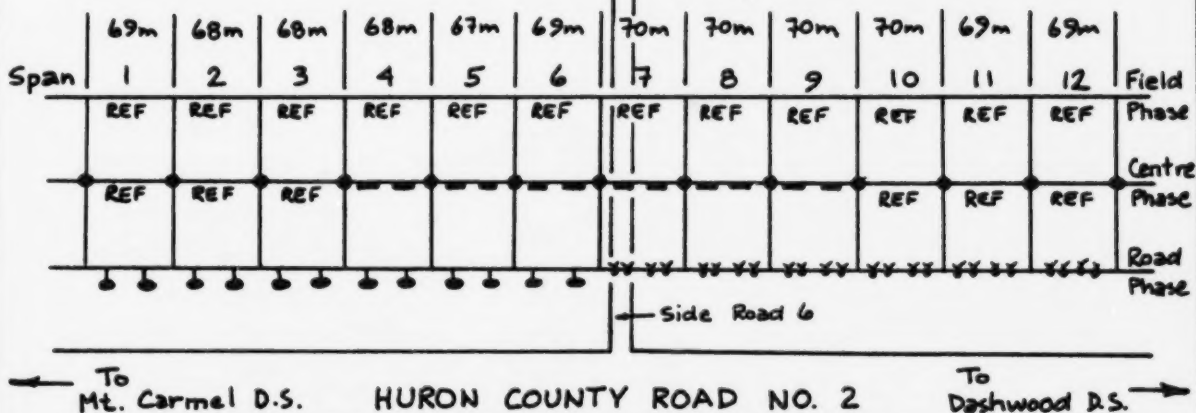
*PHASE LOCATION: N-North, S-South, E-East, W-West, U-Upper, M-Middle, L-Lower, I-Inner, O-Outer

CEA**DISTRIBUTION LINE GALLOPING
OBSERVATION DATA SHEET**Utility Name: ONTARIO HYDROTest Site Name: CLINTON-DASHWOOD JCT.Date of Observation: DECEMBER 14, 1985Observed by: RAY WILSONConductor Size (s): 556.5 kcmil - DahliaWind Speed: 14.3 m/sec (32 mph)Wind Direction: from SE to NWAir Temperature: -1°CIce Thickness (est'd): 3.2 mm (0.125 in)General Weather Conditions: OVERCAST AND RAIN

Please provide Test Site Map

Indicate: 1) Wind Direction (✓)
2) Which Spans Galloping (X)

Legend:  Detuning Pendulum (4/span)
 Air Flow Spoiler
 Russian Tee Foil
 REF Reference Phase



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 800 Kipling Avenue, KR289
 Toronto, Ontario M8Z 5S4

85-276

APPENDIX V

OBSERVATIONS AT TEST SITES IN CANADA

<u>DATE</u>	<u>TEST SITE</u>	<u>OBSERVATION NUMBER</u>
December 27, 1984	Nova Scotia Power Corp - Cheticamp	S61
February 14, 1985	Saskatchewan Power Corp - SW8	S62
March 19, 1985	Saskatchewan Power Corp - SW8	S63

DATA FROM FIELD OBSERVATIONS OF GALLOPING
AT ONTARIO HYDRO SINGLE CONDUCTOR TEST SITES

OBSERVATION NO S61

PAGE: 1 of 1

DATE: Dec. 27/84

UTILITY: Nova Scotia Power Corp				SITE: Cheticamp				VOLTAGE: 12 kV		LINE DIR'N: N-S	
CONDUCTOR NAME: ACSR-Quail				COND'R DIAMETER: 11.4 mm 0.887 in				COND'R CONST: 6/1			
CONDUCTOR SIZE: 2/0 kcmil				COND'R WT. 0.2731 kg/m 0.1831 lb/ft				AREA OF ALUM: 67.4 mm ² 0.1045 in ²			
NO OF SUBCONDUCTORS: 1				SUBCOND'R SPACING: - mm - in				AREA OF STEEL: 11.2 mm ² 0.0178 in ²			
TENSION AT 0°C: 6.8 kN 1527 lb				TORS'L STIFF: 14.5 Nm ² /r 35 ft ² ·lb/				ICE SHAPE, POSITION			
PENDULUM WT./SPAN: 5.6 kg 12.3 lb				NO OF LOCATIONS PER SPAN: 1							
PENDULUM ARM LENGTH: 234 mm 9.2 in				RADIUS OF GYRATION: 245 mm 9.7 in							
				NO OF AIR FLOW SPOILERS/SPAN: 3							
WEATHER: NA				WIND SPEED: NA m/s NA mph							
TEMPERATURE: NA °C NA °F				WIND DIRECTION: NA				ICE THICKNESS: NA mm NA in			

TIME	SPAN, TOWER NOs	SPAN LENGTH m ft	SAG m ft	GALLOPING AMPLITUDE: m ft								MAX'M THEOR AMPL. m ft	PROT'N LEVEL @ FV = 1 FT = 2	
				NUMBER OF LOOPS										
				DET'D	AFS	REF	REF	REF	REF	REF	REF			
				E *	W *	M *	*	*	*	*	*	*		
12:00am to 5:00 am	5-10	36.9- 43.3to 121- 142	0.07 43.3 121- 142	See Notes									0.239	

NOTES: This observation was taken in the middle of the night therefore only a qualitative assessment of the galloping was provided. The observer reported that on one span, the spoilers worked better than the pendulum and on another span the opposite was the case. There was one span where the phases with control devices were galloping and the inference phase was still. The observer stated that it was difficult to determine which device, if any, performed better.

*PHASE LOCATION: N-North, S-South, E-East, W-West, U-Upper, M-Middle, L-Lower, I-Inner, O-Outer

CEA**DISTRIBUTION LINE GALLOPING
OBSERVATION DATA SHEET**Utility Name: NOVA SCOTIA POWER CORPTest Site Name: CHETICAMPDate of Observation: DECEMBER 27, 1984Observed by: RICHARD LERLANCConductor Size (s): 2/0 ACSR (0.447 inches dia.)Wind Speed: NAWind Direction: from NA to NAAir Temperature: NAIce Thickness (est'd): NAGeneral Weather Conditions: NA

Please provide Test Site Map

- Indicate: 1) Wind Direction (↗)
2) Which Spans Galloping (X)

LEGEND

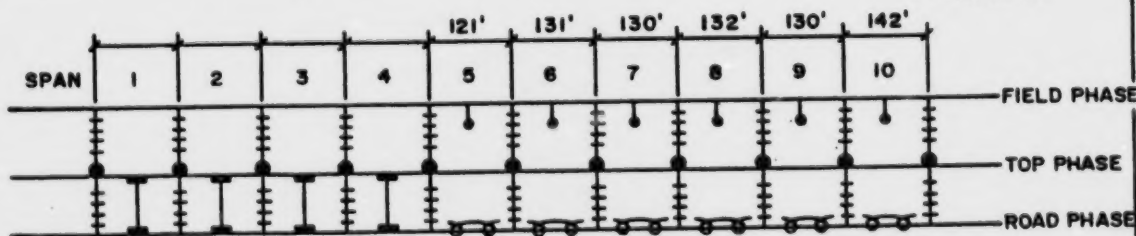
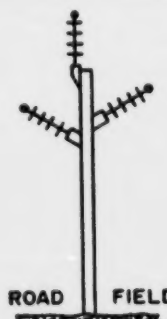
DETUNING PENDULUM (1 PER SPAN)



AIR FLOW SPOILER (3 PER SPAN)



INTERPHASE SPACER (1 PER SPAN)



TO CHETICAMP

ROUTE 19

TO BELLECOTE



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800 Kipling Avenue, KR2B9
Toronto, Ontario M8Z 5S4

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DATA FROM FIELD OBSERVATIONS OF VIBRATION

OBSERVATION NO S62

PAGE: 1 of 1

DATE: Feb. 14/85

UTILITY: Saskatchewan Power Corp				SITE: SW8				VOLTAGE: 72 kV		LINE DIR'N: E-W			
CONDUCTOR NAME: ACSR-Penguin				COND'R DIAMETER: 14.3 mm 0.563 in				COND'R CONST: 6/1					
CONDUCTOR SIZE: 4/0 kcmil				COND'R WT. 0.434 kg/m 0.2911 lb/ft				AREA OF ALUM: 107 mm ² 0.1662 in ²					
NO OF SUBCONDUCTORS: 1				SUBCOND'R SPACING: - mm - in				AREA OF STEEL: 18 mm ² 0.277 in ²					
TENSION AT 0°C 4.6 kN 1030 lb				TORS'L STIFF: 31 Nm ² /r 74 ft ² ·lb/r				ICE SHAPE, POSITION					
NO OF RTF/SPAN: 31				NO OF LOCATIONS PER SPAN: 3									
WEATHER:				WIND SPEED: 6.7-8.9 m/s 15-20 mph									
TEMPERATURE: -10°C 14°F				WIND DIRECTION: NW to SE				ICE THICKNESS: 0 mm 0 in					
TIME	SPAN, TOWER NOs	SPAN LENGTH m ft	SAG m ft	VIBRATION AMPLITUDE: m ft								MAX'M THEOR AMPL. m ft	PROT'N LEVEL
				NUMBER OF LOOPS									
				RTF	REF	REF	REF	REF	REF	REF	REF		
				M *	N *	S *	*	*	*	*	*		
3:30 PM	422- 423	146 480	2.5 8.1	See notes								-	-
Notes: This occurrence took place with no ice build up. The vibration was so severe that the weights of the stockbridge dampers of one span hit the conductor. Eventually the four weights of the dampers broke off. The most severe vibration seemed to be contained to an end span. The other spans with teefoil were vibrating as well but not as vigorously. Also observed was a torsional motion of the conductor as evidenced by the movement of the fin of the RTF. The reference phases and the phases with detuning pendulums and air flow spoilers were not vibrating.													
*PHASE LOCATION: N-North, S-South, E-East, W-West, U-Upper, M-Middle, L-Lower, I-inner, O-Outer													

DATA FROM FIELD OBSERVATIONS OF VIBRATION

OBSERVATION NO S63

PAGE: 1 of 1

DATE: Mar. 19/85

UTILITY: Saskatchewan Power Corp				SITE: SW8				VOLTAGE: 72 kV				LINE DIR'N: E-W			
CONDUCTOR NAME: ACSR-Penguin				COND'R DIAMETER: 14.3 mm 0.563 in				COND'R CONST: 6/1							
CONDUCTOR SIZE: 4/0 kcmil				COND'R WT. 0.434 kg/m 0.2911 lb/ft				AREA OF ALUM: 107 mm ² 0.1662 in ²							
NO OF SUBCONDUCTORS: 1				SUBCOND'R SPACING: - mm - in				AREA OF STEEL: 18 mm ² 0.277 in ²							
TENSION AT 0°C 4.6 kN 1030 lb				TORS'L STIFF: 31 Nm ² /r 74 ft ² ·lb/r				ICE SHAPE, POSITION							
NO OF RTF/SPAN: 31				NO OF LOCATIONS PER SPAN: 3											
WEATHER: No Precipitation				WIND SPEED: 4.5 m/s 10 mph											
TEMPERATURE: 5°C 41°F				WIND DIRECTION: SE to NW				ICE THICKNESS: 0 mm 0 in							
TIME	SPAN, TOWER NOs	SPAN LENGTH m ft	SAG m ft	VIBRATION AMPLITUDE: m ft								MAX'M THEOR AMPL. m ft	PROT'N LEVEL		
				NUMBER OF LOOPS											
				RTF	REF	REF	REF	REF	REF	REF	REF				
				M	*	N	*	S	*		*		*		*
11:00 am	422- 423	146 480	2.5 8.1	See notes								-	-		
Notes: This occurrence took place with no ice build up. The vibration was so severe that the weights of the stockbridge dampers of one span hit the conductor. Eventually the four weights of the dampers broke off. The most severe vibration seemed to be contained to an end span. The other spans with teefoil were vibrating as well but not as vigorously. Also observed was a torsional motion of the conductor as evidenced by the movement of the fin of the RTF. The reference phases and the phases with detuning pendulums and air flow spoilers were not vibrating.															
*PHASE LOCATION: N-North, S-South, E-East, W-West, U-Upper, M-Middle, L-Lower, I-Inner, O-Outer															

CEA**DISTRIBUTION LINE GALLOPING
OBSERVATION DATA SHEET**Utility Name: SASKATCHEWAN POWER CORPTest Site Name: SNADate of Observation: FEBRUARY 14 and MARCH 19, 1985Observed by: D. FELGATEConductor Size (s): 4/0 ACSR

Wind Speed: _____

Wind Direction: from _____ to _____

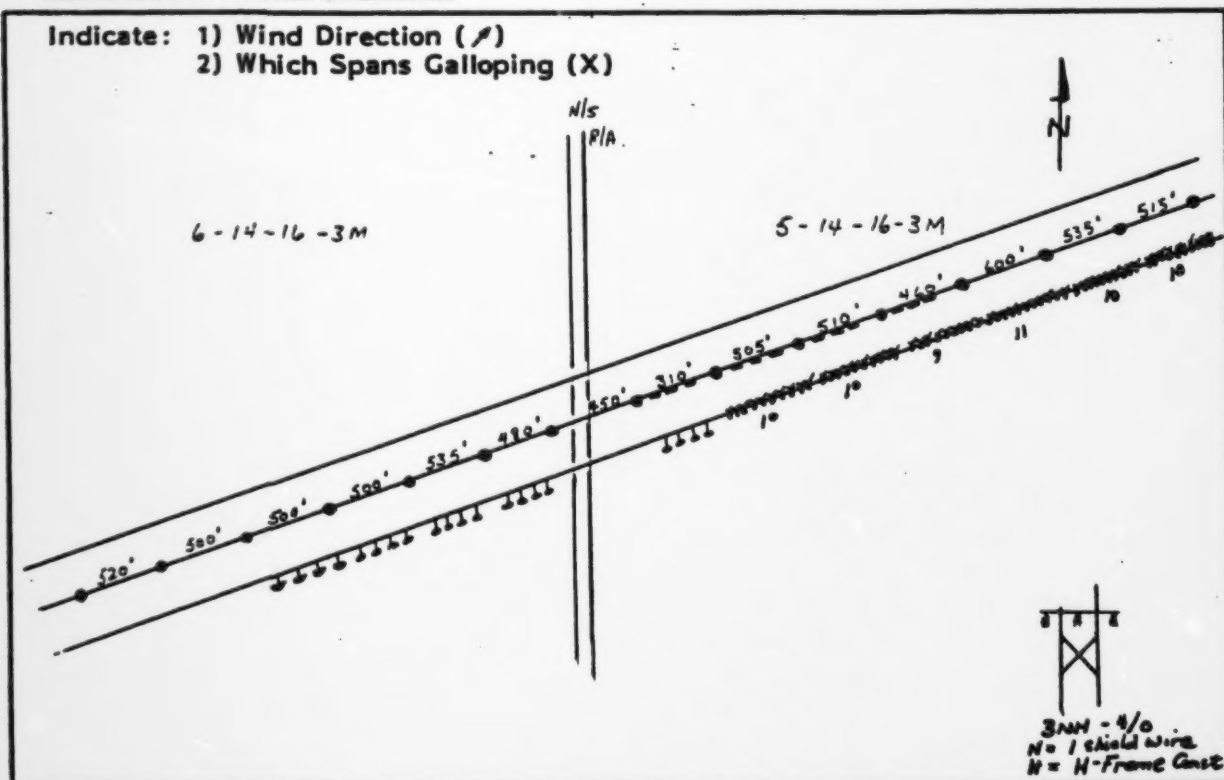
Air Temperature: _____

Ice Thickness (est'd): _____

General Weather Conditions: _____

Please provide Test Site Map

- Indicate: 1) Wind Direction (✓)
2) Which Spans Galloping (X)



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Ontario Hydro Research Division
800 Kipling Avenue, KR284
Toronto, Ontario M8Z 5S4

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APPENDIX VI

OBSERVATIONS AT SITES IN THE UNITED STATES

<u>DATE</u>	<u>TEST SITE</u>
December 13, 1984	City of Colorado Springs - Drake to Fairview
January 9, 1985	City of Colorado Springs - Cottonwood to Falcon
January 9, 1985	City of Colorado Springs - Cottonwood to Powers
December 31, 1984	Nebraska Public Power District - Geneva to Carleton
December 31, 1984	Commonwealth Edison - L11106
January 1, 1985	Commonwealth Edison - L15502

DATA FROM FIELD OBSERVATIONS OF GALLOPING

OBSERVATION NO

PAGE: 1 of 1

DATE: Dec. 13, 1984

UTILITY: City of Colorado Springs				SITE: Drake-Fairview				VOLTAGE: 115 kV		LINE DIR'N: E-W	
CONDUCTOR NAME: Filint-AAAC				COND'R DIA: 25.171 mm 0.07991 in				COND'R CONST: 37 strands			
CONDUCTOR SIZE: 740.8 kcmil				COND'R WT. 1.01 kg/m 0.6754 lb/ft				AREA OF ALUM: 375.35 mm ² 0.58/8 in ²			
NO OF SUBCONDUCTORS: 1				SUBCOND'R SPACING: - mm - in				AREA OF STEEL: - mm ² - in ²			
TENSION AT 0°C and 4.5 kN 1080 lb 3.9 kN 872 lb				TORS'L STIFF: NA Nm ² /r NA ft ² .lb/r				ICE SHAPE, POSITION			
PENDULUM WT./SPAN: - kg - lb				NO OF LOCATIONS PER SPAN: none							
PENDULUM ARM LENGTH: - mm - in				RADIUS OF GYRATION: - mm - in							
WEATHER: Freezing Drizzle				WIND SPEED: 4.47 m/s 10 mph							
TEMPERATURE: -5°C 23°F				WIND DIRECTION: Southeasterly				ICE THICKNESS: 9.5 mm 0.381 in			

TIME	SPAN, TOWER NOs	SPAN LENGTH m ft	SAG m ft	GALLOPING AMPLITUDE: m ft						MAX'N THEOR AMPL. m ft	PROT'N LEVEL	
				NUMBER OF LOOPS								
				REF	REF	REF	REF	REF	REF			
				NU *	NM *	NL *	SU *	SM *	SL *			
4:45 pm	40-41	82.3 270	1.84 6.05	3.0-4.6 10-15 NA	3.0-4.6 10-15 NA	3.0-4.6 10-15 NA	3.0-4.6 10-15 NA	3.0-4.6 10-15 NA	3.0-4.6 10-15 NA		-	-
4:45 pm	41-42	80.8 265	1.78 5.82	3.0-4.6 10-15 NA	3.0-4.6 10-15 NA	3.0-4.6 10-15 NA	3.0-4.6 10-15 NA	3.0-4.6 10-15 NA	3.0-4.6 10-15 NA		-	-
4:45 pm	42-43	125.0 410	4.96 16.3	3.0-4.6 10-15 NA	3.0-4.6 10-15 NA	3.0-4.6 10-15 NA	3.0-4.6 10-15 NA	3.0-4.6 10-15 NA	3.0-4.6 10-15 NA		-	-
4:45 pm	43-45 one span	97.5 320	3.02 9.9	3.0-4.6 10-15 NA	3.0-4.6 10-15 NA	3.0-4.6 10-15 NA	3.0-4.6 10-15 NA	3.0-4.6 10-15 NA	3.0-4.6 10-15 NA		-	-
				Note: Tension is 4.5 kN (1018 lb) for spans 40-41 and 41-42 Tension is 3.9 kN (872 lb) for spans 42-43 and 43-45								

*PHASE LOCATION: N-North, S-South, E-East, W-West, U-Upper, M-Middle, L-Lower, I-Inner, O-Outer

DATA FROM FIELD OBSERVATIONS OF GALLOPING

OBSERVATION NO

PAGE: 1 of 1

DATE: Jan, 9, 1985

UTILITY: City of Colorado Springs				SITE: Cottonwood-Falcon				VOLTAGE: 230 kV				LINE DIR'N: E-W	
CONDUCTOR NAME: AAAC				COND'R DIA: 30.38 mm 1.196 in				COND'R CONST: 37 strands					
CONDUCTOR SIZE: 1081 kcmil				COND'R WT. 1.51 kg/m 1.015 lb/ft				AREA OF ALUM: 547.7 mm ² 0.849 in ²					
NO OF SUBCONDUCTORS: 1				SUBCOND'R SPACING: - mm - in				AREA OF STEEL: - mm ² - in ²					
TENSION AT 0°C 20.9 kN 4681 lb and 17.1 kN 3845 lb				TORS'L STIFF: NA Nm ² /r NA ft ² ·lb/r				ICE SHAPE, POSITION					
PENDULUM WT./SPAN: - kg - lb				NO OF LOCATIONS PER SPAN: none									
PENDULUM ARM LENGTH: - mm - in				RADIUS OF GYRATION: - mm - in									
WEATHER: Dry				WIND SPEED: 4.47 m/s 10 mph									
TEMPERATURE: -9°C 16°F				WIND DIRECTION: North to South				ICE THICKNESS: 25.4 mm 1.0 in					
TIME	SPAN, TOWER NOs	SPAN LENGTH m ft	SAG m ft	GALLOPING AMPLITUDE: m ft						MAX'M THEOR AMPL. m ft	PROT'N LEVEL		
				NUMBER OF LOOPS									
				REF	REF	REF	REF	REF	REF				
				NU *	NM *	NL *	SU *	SM *	SL *				
4:30 pm	29-30	213 700	4.1 13.3	2.1 7 1	2.1 7 1	2.1 7 1	2.1 7 1	2.1 7 1	2.1 7 1		-	-	
5:00 pm	52-53	238 780	6.1 20.1	2.1 7 1	2.1 7 1	2.1 7 1	2.1 7 1	2.1 7 1	2.1 7 1		-	-	
5:00 p.m.	53-54	210 690	4.8 15.7	2.1 7 1	2.1 7 1	2.1 7 1	2.1 7 1	2.1 7 1	2.1 7 1		-	-	
											-	-	
				Note: Tension is 20.9 kN (4681 lb) for span 29-30 Tension is 17.1 kN (3845 lb) for spans 52-53 and 53-54									
*PHASE LOCATION: N-North, S-South, E-East, W-West, U-Upper, M-Middle, L-Lower, I-Inner, O-Outer													

DATA FROM FIELD OBSERVATIONS OF GALLOPING

OBSERVATION NO

PAGE: 1 of 1

DATE: Jan. 9, 1985

UTILITY: City of Colorado Springs				SITE: Cottonwood-Powers				VOLTAGE: 34.5 kV		LINE DIR'N: E-W		
CONDUCTOR NAME: Darlen-AAAC				COND'R DIA: 21.8 mm 0.858 in				COND'R CONST: 19 strands				
CONDUCTOR SIZE: 559.5 kcmil				COND'R WT. 0.78 kg/m 0.5252 lb/ft				AREA OF ALUM: 283.5 mm ² 0.4394 in ²				
NO OF SUBCONDUCTORS: 1				SUBCOND'R SPACING: - mm - in				AREA OF STEEL: - mm ² - in ²				
TENSION AT 0°C 9.47kN 2125 lb				TORS'L STIFF: NA Nm ² /r NA ft ² ·lb/r				ICE SHAPE, POSITION				
PENDULUM WT./SPAN: - kg - lb				NO OF LOCATIONS PER SPAN: none								
PENDULUM ARM LENGTH: - mm - in				RADIUS OF GYRATION: - mm - in								
WEATHER: Dry				WIND SPEED: 4.5 m/s 10 mph								
TEMPERATURE: -9°C 16°F				WIND DIRECTION: North to South				ICE THICKNESS: 25.4 mm 1.0 in				
TIME	SPAN, TOWER NOs	SPAN LENGTH m ft	SAG m ft	GALLOPING AMPLITUDE: m ft						MAXIM THEOR AMPL. m ft	PROT'N LEVEL	
				NUMBER OF LOOPS								
				REF	REF	REF	REF	REF	REF			
				N *	M *	S *	*	*	*			
4:30 pm	69-70	76.2 250	0.59 1.93	1.2 4 1&2	1.2 4 1&2	1.2 4 1&2					-	-
4:30 pm	70-71	76.2 250	0.59 1.92	1.2 4 1&2	1.2 4 1&2	1.2 4 1&2					-	-
4:30 p.m.	71-72	76.2 250	0.59 1.92	1.2 4 1&2	1.2 4 1&2	1.2 4 1&2					-	-
4:30 p.m.	72-73	76.2 250	0.59 1.92	1.2 4 1&2	1.2 4 1&2	1.2 4 1&2					-	-

*PHASE LOCATION: N-North, S-South, E-East, W-West, U-Upper, M-Middle, L-Lower, I-Inner, O-Outer

DATA FROM FIELD OBSERVATIONS OF GALLOPING

OBSERVATION NO

PAGE: 1 of 1

DATE: Dec. 31, 1984

UTILITY: Nebraska Public Power District				SITE: Geneva-Carleton TL 1083				VOLTAGE: 115 kV		LINE DIR'N: E-W		
CONDUCTOR NAME: ACSR-Rail Self Damping				COND'R DIA: 28.0 mm 1.1 in				COND'R CONST: 13/8				
CONDUCTOR SIZE: 954 kcmil				COND'R WT. 1.6 kg/m 1.072 lb/ft				AREA OF ALUM: 483.4 mm ² 0.7493 in ²				
NO OF SUBCONDUCTORS: 1				SUBCOND'R SPACING: - mm - in				AREA OF STEEL: 33.4 mm ² 0.0518 in ²				
TENSION AT 0°C 17.9 kN 4018 lb				TORS'L STIFF: NA Nm ² /r NA ft ² ·lb/r				ICE SHAPE, POSITION				
PENDULUM WT./SPAN: - kg - lb				NO OF LOCATIONS PER SPAN: none								
PENDULUM ARM LENGTH: - mm - in				RADIUS OF GYRATION: - mm - in								
WEATHER: Cloudy				WIND SPEED: 2.7-2.8 m/s 6-13 mph								
TEMPERATURE: -12°C 10°F				WIND DIRECTION: North to South				ICE THICKNESS: NA mm NA in				
TIME	SPAN, TOWER NOS	SPAN LENGTH m ft	SAG m ft	GALLOPING AMPLITUDE: m ft							MAX'M THEOR AMPL. m ft	PROT'N LEVEL
				NUMBER OF LOOPS								
				REF	REF	REF	REF	REF	REF			
				U *	M *	L *	*	*	*			
11:40 am	198-199	108 354	1.3 4.2	2.4 8 1	2.1 7 1	0.6 2 TW					-	-
10:30 am	233-234	118.9 390	1.5 5.2	1.8 7 1	1.2 4 1	2.1 7 TW					-	-
			Note: TW means <u>Travelling Wave</u>									

*PHASE LOCATION: N-North, S-South, E-East, W-West, U-Upper, M-Middle, L-Lower, I-Inner, O-Outer

DATA FROM FIELD OBSERVATIONS OF GALLOPING

OBSERVATION NO

PAGE: 1 of 1

DATE: Dec. 31, 1984

UTILITY: Commonwealth Edison				SITE: L11106				VOLTAGE: 138 kV				LINE DIR'N: N-S	
CONDUCTOR NAME: ACSR-Hawk				COND'R DIA: 21.8 mm 0.858 in				COND'R CONST: 26/7					
CONDUCTOR SIZE: 477 kcmil				COND'R WT. 0.98 kg/m 0.657 lb/ft				AREA OF ALUM: 242 mm ² 0.3746 in ²					
NO OF SUBCONDUCTORS: 1				SUBCOND'R SPACING: - mm - in				AREA OF STEEL: 39 mm ² 0.061 in ²					
TENSION AT 0°C 11.6 kN 2600 lb				TORS'L STIFF: NA Nm ² /r NA ft ² .lb/r				ICE SHAPE, POSITION					
NO. OF SPOILERS/SPAN: NA													
WEATHER: Freezing Rain				WIND SPEED: 4.5-6.7 m/s 10-15 mph									
TEMPERATURE: -1°C 30°F				WIND DIRECTION: East to West				ICE THICKNESS: 6.4 mm 0.25 in					

TIME	SPAN, TOWER NOs	SPAN LENGTH m ft	SAG m ft	GALLOPING AMPLITUDE: m ft								MAX'M THEOR AMPL. m ft	PROT'N LEVEL
				NUMBER OF LOOPS									
				AFS	AFS	AFS	REF	REF	REF				
				U *	E *	W *	U *	E *	W *				
2:00 - 2:30 pm	1070- 1078	103.6 340	1.1 3.7	0.6 2 2&3	0.6 2 2&3	0.6 2 2&3						-	-
2:00 - 2:30 pm	1078- 1086	103.6 340	1.1 3.7				1.4 4.5 1	1.4 4.5 1	1.4 4.5 1			-	-
3:00 pm	1070- 1078	103.6 340	1.1 3.7	0.3 1 2&3	0.3 1 2&3	0.3 1 2&3						-	-
3:00 pm	1078- 1086	103.6 340	1.1 3.7				0.9 3.0 1	0.9 3.0 1	0.9 3.0 1			-	-

NOTE: Air Flow Spoilers (AFS) are installed on all three phases of the 8 spans between towers 1070 to 1078. The 8 spans between towers 1078 - 1086 are used for reference.

*PHASE LOCATION: N-North, S-South, E-East, W-West, U-Upper, M-Middle, L-Lower, I-Inner, O-Outer

DATA FROM FIELD OBSERVATIONS OF GALLOPING

OBSERVATION NO

PAGE: 1 of 1

DATE: Jan. 1, 1985

UTILITY: Commonwealth Edison			SITE: L15502			VOLTAGE: 345 kV			LINE DIR'N: E-W			
CONDUCTOR NAME: ACAR			COND'R DIA: 33.1 mm 1.302 in			COND'R CONST: 54/7						
CONDUCTOR SIZE: 1277 kcmil			COND'R WT. 1.8 kg/m 1.199 lb/ft			AREA OF ALUM: 573 mm ² 0.888 in ²						
NO OF SUBCONDUCTORS: 2			SUBCOND'R SPACING: 457 mm 18 in			AREA OF STEEL: 74.2 mm ² 0.115 in ²						
TENSION AT 0°C 22.3 kN 5000 lb			TORS'L STIFF: NA Nm ² /r NA ft ² ·lb/r			ICE SHAPE, POSITION						
PENDULUM WT./SPAN: - kg - lb			NO OF LOCATIONS PER SPAN: none									
PENDULUM ARM LENGTH: - mm - in			RADIUS OF GYRATION: - mm - in									
WEATHER: Clear			WIND SPEED: 4.5 m/s 10 mph									
TEMPERATURE: -6°C 21°F			WIND DIRECTION: North to South			ICE THICKNESS: 3.2 mm 0.125 in						
TIME	SPAN, TOWER NOs	SPAN LENGTH m ft	SAG m ft	GALLOPING AMPLITUDE: m ft						MAX'M THEOR AMPL. m ft	PROT'N LEVEL	
				NUMBER OF LOOPS								
				REF	REF	REF	REF	REF	REF			
				N *	M *	S *	*	*	*			
2:30 pm	396- 397	358 1174	12.6 41.3	2.4-3.7 8-12 1	2.4-3.7 8-12 1	2.4-3.7 8-12 1					-	-

*PHASE LOCATION: N-North, S-South, E-East, W-West, U-Upper, M-Middle, L-Lower, I-Inner, O-Outer

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